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To offset in some measure the foregoing criticisms of the terminology of Mr. Chandler's paper let me commend his use of pial, dorsal, caudad and cephalad.

BURT G. WILDER

A FISTULA IN THE DOGFISH

IN a shipment of dogfish pups (*Mustelis canis*) sent from Woods Hole to the Biological Laboratory of New York University during the summer of 1910, there was a specimen about 20 inches long with a cœlomic fistula which had been closed in a curious manner. The opening was on the ventral surface, just posterior to the left pectoral fin. Externally it was not conspicuous, the tissue of the oval scar being much the same color as the surrounding skin, although evidently of a somewhat different texture.

On laying open the body cavity it was found that the fistula had been plugged by a growth from the left lobe of the liver, which had filled the wound completely without adhering to the structure of the body wall. The edge of the cicatrice, after the liver had been drawn away intact, was smooth and thoroughly healed.

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NOTE ON "SOME EARLY PHYSIOGRAPHIC INFERENCES"

AMONG the interesting physiographic comments quoted from early writers by Dr. Emerson on page 374 of *SCIENCE* for March 4, the one by James Hall is evidently misinterpreted. The quotation is as follows:

About midway between St. Louis and the mouth of the Ohio, masses of limestone rock are seen on either side, which, though now unconnected, have the appearance of once having formed a continuous ridge crossing the river in an oblique direction.

This is supposed by Emerson to refer to the bluffs bordering the new trough of the Mississippi River near Thebes, Ill., where it leaves its old valley and crosses into another formerly occupied by the Ohio River. It seems practically certain, however, that Hall had in

mind a conspicuous ridge of limestone beds dipping steeply northeastward, which appears on the west bank of the Mississippi in Perry county, Mo. Just below Wittenberg, this ridge has evidently been obliquely intersected by the river, the obvious southeastward continuation in a direct line appearing on the east bank in the picturesque series of isolated rock masses known locally as the Devil's Bake-oven and Devil's Backbone; the latter ending abruptly at the town of Grand Tower, Ill. This is about three fifths of the distance from St. Louis to the Ohio, while the Thebes cut is only a short distance above the mouth of the Ohio; and at the cut neither the rock masses nor the oblique direction are especially evident.

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SCIENTIFIC BOOKS

The Mechanical Factors of Digestion. By WALTER B. CANNON, A.M., M.D., George Higginson Professor of Physiology, Harvard University. Illustrated. London, Edward Arnold; New York, Longmans, Green and Co. 1911. Pp. 227.

The motor activities of the muscle tube which forms the digestive system has long been a favorite subject of investigation, and a considerable mass of valuable information is at our disposal. But this evidence often shows a marked lack of harmony, even though the observations were made upon the same organ in the same animal. The fault, however, lay not so much with the experimenters, as with the methods employed; there was no single procedure which was applicable for the study of the entire gastro-intestinal canal without grave operative interferences, and these interferences often altered or even abolished the very function which was to be investigated. It was therefore natural that varying interpretations and consequent confusion should arise. In 1896, a method was developed by means of which the motor functions of the entire digestive tube, from pharynx to rectum, could be observed without

any operation whatsoever; or the effects of operations (resection of nerves, portions of the gut, etc.) could be studied after the animal had fully recovered. Cannon achieved this result by means of the X-ray. This method depends on the fact that food mixed with a salt of bismuth (subnitrate or oxychloride; an iron salt has also been used lately) becomes opaque to the X-ray. If the subject under investigation, man, dog, cat or other animal, ingests this bismuth paste, the bolus may be observed on the fluorescent screen, for the bismuth mass blocks the X-rays and betrays its presence to the observer by a vibrating shadow on this screen. The progress and change in shape of this shadow disclose to the eye of the expert observer the character of the muscular activity of the digestive system.

Besides originating and perfecting this method Cannon has also been the foremost modern investigator of gastro-intestinal motility. The experimental results with which he enriched physiology during the last fourteen years have, however, only recently been collected by him in a monograph, and this monograph is the first authoritative attempt to give a complete, critical study of motor digestive activities as a whole, using as a guide the results gained by his new method. Although Cannon's work forms by far the largest part of our modern knowledge of the motor activities of the gut, his monograph is by no means a one-sided presentation of the results obtained by his laboratory; other important work, gained by various experimental methods, is critically considered and brought into relation with the direct testimony which the X-ray affords.

The entire subject matter is considered by Cannon in sixteen concise chapters, and the chapter headings will indicate to the reader how completely the field has been covered. I., General Features of the Movements of the Alimentary Canal, and Methods of Investigation; II., The Movements of Mastication and Deglutition; III., The Nervous Control of Deglutition; IV., Conditions Affecting the Activities of the Cardia; V., The Movements of the Stomach; VI., The Effect of Stomach

Movements on the Contents; VII., The Stomach Movements in Relation to Salivary Digestion and Gastro-enterostomy; VIII., The Passage of Different Foodstuffs from the Stomach; IX., The Acid Control of the Pylorus; X., The Correlating Functions of the Pylorus, and some Conditions Affecting It; XI., The Movements of the Small Intestine; XII., The Movements of the Large Intestine; XIII., Auscultation of Gastro-intestinal Sounds; XIV., The Intrinsic Innervation of the Gastro-intestinal Tract; XV., The Extrinsic Innervation of the Gastro-intestinal Tract; XVI., Depressive Nervous Influences Affecting Gastro-intestinal Movements. At the end of each chapter a complete list of the more important literature references is given, and this list will be a great convenience for many research workers.

While these chapter-headings show the scope of the book, they give no indication of their interesting, and attractively presented, contents. Although it is not possible here to discuss all the valuable and interesting sections of the book, and they will be found in every chapter, attention may be called to Cannon's theory of the acid control of the pylorus. The pylorus, a sphincter muscle which guards the opening of the stomach leading to the intestine, regulates the passage of the food into the duodenum (upper part of the small intestine). Depending upon the character and state of the food in the stomach, this gate-keeper feeds at intervals a spurt of food into the gut. By what mechanism is this accomplished? How can this ring of muscle-fibers differentiate, for example, between carbohydrates, which are permitted to leave quickly, and proteids, which remain for a considerable period of time in the stomach?

This remarkable behavior of the pylorus was first explained satisfactorily by Cannon, and his theory, in brief, is as follows: Free acid above the sphincter causes a relaxation of the muscle ring and a peristaltic wave is thus able to discharge a quantity of chyme into the duodenum. But as soon as the chyme reaches the duodenum, its acidity produces a closure of the pylorus. The acidity of the

chyme, however, is soon neutralized by the alkaline bile and pancreatic juices, and then the free acid in the stomach produces again an inhibition of the sphincter tonus and another quantity of chyme is driven out. This hypothesis has been tested by Cannon in numerous ways. He has shown, for example, that anything which delays the appearance of free acid delays the onset of the discharge from the stomach; that hastening the appearance of free acid hastens the time of discharge; and by means of a fistula, he was able to observe that the appearance of free acid closely precedes the first gastric discharge into the duodenum. In addition, Cannon showed that free acid causes opening of the pylorus in the *excised* stomach of a cat, thus proving that the control of the pylorus is independent of the central nervous system and resides probably in the local nerve plexus. Free acid, therefore, above the gastric sphincter causes it to relax, and this explains why carbohydrates leave the stomach much earlier than proteids, for both these food-classes stimulate the secretion of gastric juice, as Pavlov has shown, but the proteids unite with the acid as it is produced, forming acid albumen; there is thus no free acid available for a considerable period of time, and, as shown above, free acid is necessary to cause a relaxation of the pylorus. There is no such difficulty with carbohydrates; as soon as the free acid appears the pylorus relaxes, and the crackers, potato-mush, or whatever carbohydrate was fed, is at once transferred to the gut by the peristaltic waves of the stomach.

The evidence that free acid *below* the sphincter, in the duodenum, causes closure of the pylorus, is just as conclusive, for various investigators had shown that acid in the duodenum slows the output of chyme from the stomach, and this must be due to an effect on the pylorus, for Cannon demonstrated that gastric peristalsis was not stopped during this condition. Another support was furnished by the observation of Pavlov that acid solutions leave the stomach much more slowly in dogs with a pancreatic fistula than in normal animals. This is easily explained by the

fact that absence of the alkaline pancreatic juice permits the chyme to remain acid in the duodenum for a longer period, and thus the stimulus which causes closure of the pylorus remains effective until the food material becomes neutral or alkaline. Cannon studied the effects of ligation of the larger pancreatic and bile ducts on the rate of discharge from the stomach and gives a chart which shows the marked delay caused by this interference. The stimulus which causes the closure of the pylorus is mediated through the myenteric nerve plexus, for after severance of the entire muscular coats of the duodenum just below the pylorus, Cannon found that the discharge of the stomach content was considerably more rapid than in normal animals: the acid chyme undoubtedly still produced its usual stimulus in the duodenum, but this stimulus could not reach its destination, the pyloric sphincter, because its path had been destroyed.

From the foregoing it will be seen that Cannon's theory seems adequately and simply to explain one of the most remarkable functions in the body, and it is of theoretical interest that the same agent may exert diametrically opposite effects, the sign of this effect being dependent upon the locus of the stimulation.

It may be said, in short, that this concise monograph by Professor Cannon gives a balanced and authoritative view of the present state of our knowledge regarding the motor mechanism of digestion under normal and experimentally modified conditions. In addition, the reader will find that the presentation is lucid and that dogmatic statements are absent.

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CHEMICAL TEXT-BOOKS

The Elements of Qualitative Chemical Analysis with Special Consideration of the Application of the Laws of Equilibrium and of the Modern Theories of Solution. By JULIUS STIEGLITZ, Professor of Chemistry in the University of Chicago. Parts I. and II. Fundamental Principles and their Ap-